VOLUME 77 SEPARATE No. 65

PROCEEDINGS

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

APRIL, 1951

NATIONAL TOPOGRAPHIC MAPPING

By W. E. Wrather

SURVEYING AND MAPPING DIVISION

Copyright 1951 by the AMERICAN SOCIETY OF CIVIL ENGINEERS
Printed in the United States of America

Headquarters of the Society
33 W. 39th St.
New York 18, N.Y.

PRICE $0.50 PER COPY

The Society is not responsible for any statement made or opinion expressed in its publications

---

HINTS TO AUTHORS

Those who are planning papers for submission to PROCEEDINGS *will expedite Committee action measurably by first studying the standard instructions as to style, content, and format. For reprints, address the Manager, Technical Publications, 33 W. 39th St., New York 18, N. Y.*

Published at Prince and Lemon Streets, Lancaster, Pa., by the American Society of Civil Engineers. Editorial and General Offices at 33 West Thirty-ninth Street, New York 18, N. Y. Reprints from this publication may be made on condition that the full title of paper, name of author, page reference, and date of publication by the Society are given.

Proceedings—Vol. 77 April, 1951 Separate No. 65

AMERICAN SOCIETY OF CIVIL ENGINEERS

Founded November 5, 1852

PAPERS

NATIONAL TOPOGRAPHIC MAPPING

By W. E. Wrather[1]

Synopsis

The present status of topographic mapping of the United States and its possessions leaves much to be desired. Many of the maps are inadequate, and most are in danger of becoming obsolete. Changing standards and requirements have increased the rate of obsolescence.

The United States Geological Survey (USGS) has cooperated successfully with other federal and state agencies to produce maps that were valuable in the planning and supervision of many projects. Mapping standards of the Geological Survey are discussed.

An expanded, comprehensive mapping program is proposed to expedite future work in this field and to eliminate unnecessary duplication of work.

Introduction

The United States has long been recognized as a land of unlimited opportunity. Settlers from all points of the compass and from every continent have flocked to its shores since Columbus and his contemporaries first discovered this hemisphere. The early pioneers found a land of abundant natural resources. With the lavish abundance of nature on every hand, there seemed no need for conservation, so they indulged in many wasteful practices which decimated the nation's wildlife and destroyed large areas of forest. These conditions prevailed when the United States Department of the Interior was created as the "Home Department" in 1849. One of its primary functions was to establish practical conservation for the proper use of national resources.

The Basis for Practical Planning

Its natural resources have provided the means for the development of the nation's industrial might and have made possible the highest standard of living in the world. Many of these resources and raw materials, which formerly

Note.—Written comments are invited for publication; the last discussion should be submitted by October, 1951.

[1] Director, United States Geological Survey, Washington, D. C.

seemed plentiful, cannot now fully supply national requirements, and virtually no resources are overabundant in relation to anticipated needs. The United States is still a land of opportunity, but to maintain its progress and position of leadership requires all possible tools and facilities, coupled with vigorous development and comprehensive conservation policies.

One of the primary national requirements is a sound knowledge of the terrain in every part of the country. Good topographic maps which provide such information are versatile, fundamental tools that can be of service in solving a variety of urgent problems. In the past these maps have not always been available when needed, and plans for future development should be made to provide adequate, accurate mapping coverage.

After the Civil War, the need for reconnaissance and exploratory maps of the West was partly met by the work of the Wheeler, King, Hayden, and Powell surveys.[2, 3] These expeditions produced small maps of large areas (small-scale maps) which provided general rudimentary geographic knowledge for the location of transportation routes, and otherwise met the needs of a pioneer population. However, it was not until the USGS was organized in 1879 "to classify the public lands and to examine the geologic structure" that topographic mapping was undertaken as a continuing national program.

Organized Topographic Mapping

Small-scale reconnaissance mapping was continued by the Geological Survey until about 1900 when one third of the United States had been charted. As the development of the country progressed, the trend in map requirements was toward larger scales, more detail, and greater accuracy, which led to the adoption, at about 1900, of the standard scale of 1:62,500 (approximately one inch to a mile). The quality of the maps constantly improved as better instruments were designed and new methods developed.

During the 1930's it became apparent that higher standards of accuracy were needed to insure that the national series of quadrangle maps would be suitable for all major uses, and also would be of such quality that they could be conveniently revised at any time in future years. Such standards were adopted, and as a result, modern maps produced by the Geological Survey should be adequate for an unlimited period, except for occasional revision required by changes in man-made, or so-called "cultural," features.

Considerable credit must go to the various states for much of the mapping that has been done. Local cooperation has been encouraged, and several states (especially in the East) have underwritten extensive cooperative mapping programs since this policy was established in 1885. In 1930, Connecticut, Delaware, Maryland, New Jersey, New York, Ohio, Rhode Island, West Virginia, the District of Columbia, and the Hawaiian Islands were completely represented by maps which were considered adequate at that time. Unfortunately, maps, like automobiles, do not improve with age but suffer obsolescence rapidly.

[2] "Contributions to the History of American Geology," by George P. Merrill, U. S. Govt. Printing Office, 1906.

[3] "Service Monographs of the United States Government, No. 1, The U. S. Geological Survey," by the Institute for Government Research, D. Appleton & Co., New York, N. Y., 1918.

By 1950, topographic map coverage was complete on approximately one half of the total area of the United States. However, because of changing requirements and higher standards of accuracy, much of this mapping was of questionable value. Actually, only Massachusetts and Rhode Island were then completely covered with adequate maps, and only one fourth of the entire United States could be considered adequately charted.

Several attempts were made to inaugurate a long-range federal mapping program during the years that followed World War I. The Temple Act, which was passed by Congress in 1925, provided an initial appropriation of approximately $1,000,000 to be increased yearly until the United States was completely mapped. Although the program was thus approved in principle, funds were not appropriated to implement it. Federal funds directly appropriated for topographic mapping for 1935 were less than $200,000, or about the sum provided in 1885.

The failure to implement the Temple Act resulted in a serious lack of maps required for planning national defense against invasion when World War II started. It was necessary at that time, therefore, to produce maps for military use as rapidly as possible by utilizing all available facilities at a time when these facilities were also needed in the mapping of foreign areas closer to the immediate scenes of military action. Since trained technical personnel were not available in sufficient numbers and since really modern equipment was not available in quantity, many of the maps prepared as part of this emergency program are substandard. It has been necessary to remap some of these areas, and many more must eventually be remapped. It is inconceivable that a recurrence of this deplorable situation, with its inevitable waste of public funds, will ever be permitted. Intelligent planning on a national scale, for both civilian and military needs, requires good topographic maps, and the demonstrated need demands a long-range program to accomplish this objective.

Planned development under way at the close of 1950 or proposed by federal and state governments promises to result in construction programs of a magnitude heretofore unknown in the history of the nation. Proposed federal expenditures during the next several decades for water resource projects alone are estimated to cost more than $52,000,000,000. E. R. Needles,[4] M. ASCE, has stated that $60,000,000,000 and fifteen to twenty years would be needed to extend and improve the highway system for handling present and anticipated traffic. The improvement of airports and related facilities is another construction program that will also require billions of dollars before 1960. With current and proposed development programs of such unprecedented magnitude in prospect, it would seem that one of the first requisites for comprehensive planning—complete topographic information—should be available. Unfortunately, adequate maps of the required standards are not now available. This is a serious situation because it cannot be alleviated over night.

It is axiomatic that carefully prepared plans are a prerequisite to the success of any major project. Planning is greatly handicapped when basic information

[4] "Enter the Road Builders," by E. R. Needles, *Fortune Magazine*, November, 1949, p. 109.

is lacking. In fact, the ultimate success or failure of a project can depend on the availability of adequate fundamental data. Accurate topographic maps provide essential basic data in many engineering activities and should be available for preliminary as well as for detailed planning.

Value of Maps in Development Projects

When the Tennessee Valley Authority (TVA) was first established in 1933, Arthur E. Morgan, M. ASCE, was appointed chairman and chief engineer. Mr. Morgan immediately recognized the need for complete map coverage for a basin-wide program of land and water development. An analysis of the status of mapping for the 40,000 sq miles of the Tennessee River Valley revealed, in general, that no adequate maps of the basin existed, although reconnaissance maps were available for some areas. The Corps of Engineers, United States Department of the Army, had prepared strip topography for many sections of the main river and for some of the tributaries.

Under Mr. Morgan's direction, studies were made of several mapping proposals and a program for complete topographic mapping in cooperation with the USGS was decided upon. Although mapping operations were somewhat curtailed during World War II, by 1950 about 85% of the valley had been covered by topographic maps published on the scale of 1:24,000.

These topographic quadrangles have been used constantly by the various divisions of the TVA engaged in numerous activities within the basin. Discussing the value of topographic maps before the American Congress on Surveying and Mapping, Reed A. Elliot, Chief of the Project Planning Branch of TVA, said,

> "It would be practically impossible to exaggerate the value of high-grade topographic maps for the preliminary planning of water control projects such as those of the TVA system. Most of the considerations that contribute toward the final selection of the dam sites and the degree of development are, of course, directly or indirectly dependent upon the available maps."

He also said that in the case of highway relocations, tremendous savings were effected by the use of these maps. Locations were plotted on the maps from which it was usually possible to select the final route in the office.

Other important related uses of topographic maps by the TVA include malaria control, forest resource investigations, watershed protection planning, recreational development, general management of reservoir areas, and the selection of industrial sites to suit specific requirements. In addition to these uses, the topographic maps are available for the operation of existing projects and the planning of all future TVA development.

Although a sizable topographic mapping program is contemplated for the Missouri River Basin, topographic map coverage is sparse for the Pacific Northwest and for many other areas of great potential development. Adequate programs of topographic mapping should be initiated throughout the West to enable the sound and economic planning of any contemplated development projects. Undoubtedly topographic maps will be made at one time or an-

other for the entire United States. The value of a planned mapping program is in having accurate terrain information available when needed to expedite contemplated developments.

Progress in the Mapping Program

The extensive mapping operations of the Geological Survey cover a broad territory throughout the forty-eight states, Alaska, Hawaii, and Puerto Rico. Map preparation is a slow and painstaking process, and the annual production is limited to approximately 500 quadrangle sheets, or to an equivalent ground area of 50,000 sq miles. It would require fifty years to complete the adequate mapping of the entire United States at this rate.

Government agencies and private individuals have condemned this slow rate of progress. A coordinated assembly and careful analysis of basic data on topography, geology, water, and soils prior to authorization of large federal projects have been strongly recommended. Given the necessary personnel and equipment, an accelerated program of topographic mapping would make coverage of the unmapped and inadequately mapped areas of the United States possible by 1970.

This proposal would involve a considerable expansion of skilled personnel and the manufacture of additional equipment for the application of photogrammetric and other modern techniques.

Mapping Standards.—The Geological Survey has adopted two publication scales for the standard topographic maps of the United States. The larger scale of 1:24,000 is used for most urban areas and sections of major economic importance, whereas areas of lesser importance are published on the scale of 1:62,500. The demands of map users for the publication of maps on the former scale have been increasing during the past several decades to meet their requirements for more detail and smaller contour intervals. The use of this larger scale results in higher mapping costs per acre but produces maps of greater utility. Under the proposed expanded program, about half of the unmapped area of the continental United States would be covered by maps published on the 1:24,000 scale. The remaining half of the unmapped area and about a third of Alaska would be covered for map publication on the scale of 1:62,500, and the remaining two thirds of Alaska on the 1:250,000 scale.

The mapping schedule would be based on priorities determined by an appraisal of the map requirements of federal and state agencies and other map users. Concurrent with the mapping of new areas, maps previously completed would be revised periodically to overcome obsolescence. After the completion of the twenty year program, maps would be revised as necessary to maintain their full usefulness.

The estimated cost of this topographic mapping averages twenty-five cents per acre. With about three fourths of the United States to be mapped, the estimated cost of a twenty-year mapping program would be between four hundred and five hundred million dollars. This is only a fraction of 1% of the total estimated cost of anticipated federal and state construction and development programs.

Valuable By-Products

Many incidental benefits would be realized through full activation of an expanded topographic mapping program. Aerial photographs would be available in broad areas a year or two before completion of the maps, and those photographs would often serve the immediate critical needs of many agencies and individuals. Copies of the original large-scale manuscript map could be supplied upon request many months in advance of publication. Other by-products of topographic mapping are the geodetic control and general geographic knowledge garnered during field surveys and editorial processing.

One of the greatest needs, commonly recognized by government and public alike, is for an authoritative center where information may be obtained on the availability of maps, aerial photographs, geodetic control and related data, and on the status of current and planned mapping operations. The Map Information Office of the Geological Survey has been expanded to provide this much-needed clearing house. This facility is available to the general public as well as to federal and state agencies.

Conclusion

The USGS, which is the principal mapping agency of the federal government, has received strong endorsement for the expansion of the national mapping program from the Conference of State Governors, the Inter-Agency River Basin Committee, the Bureau of Public Roads, the United States Army, and many other public organizations and interested groups. Critical evaluation of the nation's mapping needs and establishment of a logical, comprehensive plan of map development are steps toward this expansion. The Geological Survey is prepared to pursue vigorously whatever mapping operations may be required of it.

AMERICAN SOCIETY OF CIVIL ENGINEERS

OFFICERS FOR 1951

PRESIDENT

GAIL A. HATHAWAY

VICE-PRESIDENTS

Term expires January, 1952:

FRED C. SCOBEY
ALBERT HAERTLEIN

Term expires October, 1952:

WILLIAM R. GLIDDEN
DANIEL V. TERRELL

DIRECTORS

Term expires January, 1952:

WALDO G. BOWMAN
MORRIS GOODKIND
HAROLD L. BLAKESLEE
PAUL L. HOLLAND
EDMUND FRIEDMAN
S. T. HARDING

Term expires January, 1953:

OTTO HOLDEN
FRANK L. WEAVER
GORDON H. BUTLER
LOUIS R. HOWSON
G. BROOKS EARNEST
WALTER J. RYAN
GEORGE W. LAMB

Term expires October, 1952:

MILTON T. WILSON

Term expires October, 1953:

KIRBY SMITH
FRANCIS S. FRIEL
WALLACE L. CHADWICK
NORMAN R. MOORE
BURTON G. DWYRE

PAST-PRESIDENTS

Members of the Board

FRANKLIN THOMAS
ERNEST E. HOWARD

TREASURER
CHARLES E. TROUT

EXECUTIVE SECRETARY
WILLIAM N. CAREY

ASSISTANT TREASURER
GEORGE W. BURPEE

ASSISTANT SECRETARY
E. L. CHANDLER

PROCEEDINGS OF THE SOCIETY

SYDNEY WILMOT
Manager of Technical Publications

HAROLD T. LARSEN
Editor of Technical Publications

COMMITTEE ON PUBLICATIONS

WALDO G. BOWMAN

FRANCIS S. FRIEL
S. T. HARDING
NORMAN R. MOORE
OTTO HOLDEN
LOUIS R. HOWSON